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PHYSICS.—*The Ether.*[1] P. G. NUTTING, Bureau of Standards.

The whole of theoretical Ether-Physics has been profoundly modified within the past two decades. Many of the fundamental concepts of electricity, gravitation, radiation and even matter itself have been revised from their foundations. Our task today is to examine the storm center, the ether. In anticipation, it may be stated that the task will prove not to be a mortuary one, but rather one of removing and getting rid of rubbish. The new ether is the old ether freed from useless and incongruous attributes.

What we wish to know about the ether is whether it exists or not, what are its nature and properties, and what are its relations to electricity, gravitation, radiation, induction and chemical affinity. Material bearing on these problems is scanty and we can do little more than review the experimental facts and their interpretation, contrasting their present interpretation with that of twenty years ago and placing in their proper setting the more recent important discoveries.

First then as to the *existence of the ether.* We shall discuss first the evidence in favor of an ether and then sum the evidence against it. The older reasons for supposing the existence of the ether hold as forcibly today as they ever did and to these have been added a few new ones of some significance.

1. There is the old question of *action at a distance.* Wherever two objects are attracted toward or repelled from each other and

[1] Presented before the Physics Association of the Bureau of Standards, February 5, 1912.

there is no material connecting link, such as a wire or pulsating fluid, between them, it has always been customary to put the burden upon an immaterial medium. Gravitational attraction, electrical and magnetic attraction and repulsion are of this nature. Chemical affinity should probably be included but some hold that a material link actually holds the atoms together.

In my opinion not much weight can be attached to action at a distance as evidence for the existence of an ether. The assumption of an ether is doubtless the *simplest* explanation of the facts, but it is certainly not the *only possible* explanation. It is easy to imagine an intervening medium pulled by one body and itself pulling a second body. However, in imagining such a medium, we are endowing it with mechanical properties and with such extreme properties as no known material possesses. In discarding the mechanical assumption we may either assume a non-mechanical ether or else assume that these forces really belong to some higher mechanical system in which the apparent action at a distance is in reality contact action. Perhaps there are still other alternatives. I merely cite these two to show how far we are from a final disposition of the problem.

2. The *propagation* of *electromagnetic energy* from one body to another. Radiation is emitted by one body and received after an interval of time by another. Where and what was this energy during that interval of time? Until recently, these questions were readily answered; radiation travels as wave energy, where waves are there is *motion*, where motion is there is something that *moves*, namely, the ether. At present with an ether devoid of mechanical properties, there are wide differences of opinion as to just how electromagnetic energy travels through space, but if we knew how it is propagated through any material di-electric, we could very probably give at least a tentative explanation of how it travels from one body to another.

So far as we now know, such energy could be propagated through *void* space only in corpuscular form. If we assume corpuscular light, we have to contend with a solid array of firmly established facts. Further, electromagnetic theory itself shows that energy thus propagated is essentially *alternating* in character and in definite relations to the direction of propagation. To my mind,

all the evidence afforded by the propagation of radiation through space is against that space being void and in favor of an ether with very definite electric and magnetic but without mechanical properties.

3. A third group of evidence bearing on the existence of the ether consists in those phenomena indicating a storage of energy in the neighborhood of an electric charge in actual motion. These phenomena correspond with self induction in the case of ordinary electric currents. Cathode ray particles, the Beta particles from radium and similar objects carrying electric charges with high velocities, carry more energy than corresponds with their material mass and velocity, electro-magnetic energy of the adjacent medium. This may even be separated from the matter and charge and measured as energy in the form of Röntgen or of Gamma rays.

These phenomena, to my mind, supply the most direct evidence of the existence of a medium. If there were no medium how could a moving charge carry or conduct along with itself, *outside itself* energy of motion. How could a bullet moving in void space possess energy of motion exterior to itself? It may be thought that the assumption of lines and tubes of force as physical entities would provide an escape from the assumption of a medium. But such an assumption merely displaces the dilemma. If we consider that the region adjacent to a moving charge is filled with actual tubes of force instead of merely being an electromagnetic field, how, without a medium, could the sizes and shapes of these tubes be a function of the velocity of the charge.

4. To most of us it is a significant fact that not one of those whose work has been largely instrumental in the overthrow of the mechanical theory—H. A. Lorenz, Poincaré, Planck, Larmor, J. J. Thomson, Schuster, Whittaker, Heaviside, Wiechert, or Michelson—appears to question the existence of an ether *without* mechanical properties.

The no-ether school may fairly be compared with the no-atom school of Energetics. If we ignore the ether or the atom we may treat a considerable portion of physics quite satisfactorily but we must ignore a great many vital and significant phenomena in so doing.

The evidence *against* the existence of the ether falls into two distinct classes; it is either evidence against the *mechanical* theory or else evidence based on the negative results of attempts to detect ether drift. In the last analysis these two are the same but we shall discuss them separately.

The mechanical theory never did have high standing with thinking men, and but for the support of a few leading physicists having mechanical minds, would never perhaps have been developed beyond a mere tentative hypothesis. We have no reason to think that even Lord Kelvin himself, chief exponent of the mechanical theory, ever considered it more than such a working hypothesis.

We are all familiar with the character and properties assigned to the mechanical ether; its enormous elasticity and infinitesimal density to give the proper value to the velocity of light, its enormous tensile strength to support gravitational forces, its solid properties to propagate transverse light waves, its fluid properties to permit heavenly bodies to move through it with fixed velocities, and so on. The mechanical ether reached its highest development as a vortex sponge at the close of the last century. It has passed away, not by violence but by starvation. It always was a monstrosity and we are only too glad to be able to discard it forever.

The stubborn refusal of all phenomena, both natural and artificial, to show any indication of absolute motion in space has no direct bearing on the question of the existence of an electromagnetic ether. The Lorenz contraction hypothesis, with the electron theory of matter, offers us one loophole of escape from the stubborn facts, the relativity theory several. It is too early to say what will be the outcome, into what framework of theory, our experimental facts will fit with least violence to themselves.

Some relativists would have us reject the ether entirely on the ground that it is useless. I, myself, fail to see how it can be dispensed with, any more than atoms or molecules can be dispensed with, nor how anyone, at all versed in theoretical optics or electricity, can consider it unnecessary.

In short, the mechanical ether of Kelvin, Lodge and Helmholtz, the ether most of us were brought up on, has been proven

untenable, the electromagnetic Maxwell ether stands just where it always stood. It has been attacked, without much effect, by the extreme relativists, strengthened by the electron theory and brought into prominence by the pruning away of the mechanical theory.

As the conservation of energy is the simplest general principle which will make perpetual motion impossible, so the simplest physical law that will permit of discarding all the mechanical attributes of the ether is the principle of relativity. Each of these principles are, however, but limited forms of more general laws.

Before outlining the properties of the ether let us consider briefly its mathematical framework in the newer physics of which the relativity theory is the most conspicuous landmark. Mathematical physicists (Lorenz, Minkowski, Abraham, Einstein) have found that apparent experimental contradictions disappear and the mathematical framework of physics is greatly simplified if, instead of referring phenomena to a set of three space axes and one time axis of reference, they are referred to a set of *four* interchangeable axes involving 4 homogeneous coördinates, three of space and one of time. There are an infinite number of ways of projecting the four dimensional (x, y, z, t) space into the x, y, z, and t space. Phenomena that are ambiguous and contradictory when one projection is used are simple and harmonious with another projection. Further, if a star, say, is in motion relative to one x, y, z, t system, it will be at rest with respect to some other system of axes. Relativity is a particular instance of the application of these principles. Already gravitation, that most recondite of all physical facts, is yielding to this four dimensional analysis. What we have here to keep in mind is that in order to explain the lack of ether drift it is unnecessary to annihilate or ignore either space or time intervals but merely to generalize our axes of reference.

Three classes of physical phenomena may take place within or across space void of matter:

(a) *Forces* may *act*. Electric, magnetic, gravitational (and possibly chemical) forces act across space even when no matter inter-

venes. Electric and magnetic forces may be either positive or negative, gravitational and chemical forces are negative only. The signs of these forces can not be altered by any intervening medium. Electric forces are a maximum when no matter intervenes. Magnetic forces are intermediate in value while gravitational force is the same whatever the intervening medium. The speed of propagation of electric and magnetic forces across space is a finite constant independent of the sign or magnitude of those forces. The speed of propagation of gravitational forces is certainly greater than 10^{14} cm/sec and probably infinite. In no case is there any evidence of a force too small or too great to be propagated; that is of any finite maximum or minimum load. In other words, there is no evidence that the ether, if the ether be responsible, has any finite inertia or viscosity on the one hand or breaking strength on the other, certainly not in any mechanical sense.

(b) The absence of matter is no bar to *induction*. An electric charge induces an electric charge as readily across a vacuum as through matter, and similarly with magnetic and electromagnetic induction. Induction is always of the same sign, unlimited in magnitude and propagated with the speed of light.

(c) Electromagnetic radiation is propagated across a vacuum as freely as through matter. Beams of light and electric waves, whatever their nature, travel independently of each other, i.e., no matter how filled with radiation of *one* kind and direction a certain space is, neither the wave length, velocity, direction, damping or polarization of any other beam traversing the same space at the same time is in any way affected. Neither electric nor gravitational *strain* of any amount produces birefraction in a space devoid of matter nor does a magnetic field affect the *plane of polarization* unless matter be present. That these effects do exist in matter indicates an actual mechanical strain. Of the two astronomical methods for determining the velocity of light, the satellite method gives the *group* velocity, while the aberration constant gives the *wave* velocity; the close agreement between the values obtained indicates that wave and group velocity is the same, hence that there is *no* dispersion in space, waves of all frequencies travel with the same velocity.

Two important facts give us clues to the actual magnitudes of the constants of the ether (a) the fixed finite nature of the velocity of propagation (independent of the motion or intensity of the source) indicates definite electrodynamical properties in the space traversed, in fact that

$$c = (k\mu)^{-\frac{1}{2}}$$

We but require a second independent relation between c, k, and μ to determine the actual values of k and μ for the ether. (b) Again, space has a definite fixed *capacity* for radiant *energy*, a function of the frequency of the radiation, its spectral distribution, the velocity of propagation and the amount already present. Expressions for what correspond with entropy and specific heat may be derived without difficulty. This capacity for energy is dependent upon boundary conditions while the velocity constant is *not*.

There exists rather conclusive evidence that short wave and pulse electromagnetic energy is emitted in even multiples of a small but finite quantity proportional to the frequency. On the other hand there is no evidence that such is the case with the long waves of wireless telegraphy. However, it does not follow that even light waves or gamma rays are necessarily propagated in space in these discrete units. A spherical wave or pulse may be subdivided radially by an absorbing screen, a lens or a mirror; tangentially by partial absorption or reflection or by double refraction and there is no evidence of any limit to the attenuation a pulse or wave may suffer during propagation.

To summarize the properties of the ether we may say that it has no *mass* and no *ridigity* in the mechanical sense and that its parts have no *identity*. Having no mass it can have no *density*, having no rigidity it cannot be subject to *strain*. The ether does, however, possess electromagnetic properties analogous to each of these.

Having no identity, its displacements and velocities, if it has any, are unknown to us. Tagging the ether with electromagnetic disturbances is, as we have seen, ineffective. The core of the matter is this: What kind of a medium can have *real tangible*

forces acting at its boundaries and conduct real energy with a finite velocity and yet itself have no inertia or rigidity in any mechanical sense.

Two of the many possible explanations are suggested. (1) the properties of the ether may be mechanical after all but in four dimensions. If this be the case it is for the mathematical physicist to work out the solution of the problems of gravitation, induction and radiation; it would be useless for the experimental physicist working in three dimensions to seek a solution. Or (2) the properties of the ether may be non-mechanical of unknown nature. In this case, it is for the experimentalist to find out the nature of electricity and ponderomotive electrical effects. The four dimensional mathematical method appears to be the only one capable of attacking the gravitational field; yet we feel instinctively that the final solution *must be* physical and three dimensional.

PHYSICS.—*Thermometric lag.* D. R. HARPER 3RD. Communicated by C. W. Waidner. To appear in the Bulletin of the Bureau of Standards.

The transfer of heat from any medium to a mercurial thermometer of the common "chemical" type may be expressed with a high degree of accuracy by the relation

$$\frac{d\theta}{dt} = \frac{1}{\lambda}(u - \theta) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

θ = temperature of thermometer (average) at time t
u = temperature of medium at same instant
λ = a "constant" with respect to θ, u, and t.

λ is not an absolute constant of a given thermometer but depends upon the medium in which it is immersed and the rate at which the meduim is stirred. By equation (1) it is seen that λ has the dimensions of time, and it may be interpreted as a definite number of seconds:

1. If a thermometer has been immersed for a long time in a bath whose temperature is rising at a uniform rate, λ is the number of seconds between the time when the bath attains any given

temperature and the time when the thermometer indicates this temperature; i.e., the number of seconds the thermometer lags.

2. If a thermometer be plunged into a bath maintained at a constant temperature (the thermometer being initially at a different temperature), λ is the number of seconds in which the difference between the thermometer reading and bath temperature is reduced to ϵ^{-1} times its initial value.

From a series of thermometer readings (θ) obtained at sufficiently close intervals, the variation of θ with t may be considered as given and the value of the temperature (u_1) corresponding to any thermometer reading (θ_1) is at once obtainable by employing (1) in the form

$$u_1 = \theta_1 + \lambda \frac{d\theta}{dt}\Big]_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Conversely θ may be obtained from u, i.e., the behavior of the thermometer in a bath whose temperature varies with time according to some given law, can be predicted from the solution of the differential equation. The general solution is

$$\theta - u = (\theta_o - u_o)\,\epsilon^{-\frac{1}{\lambda}t} - \epsilon^{-\frac{1}{\lambda}t} \int_o^t \frac{\partial u}{\partial t}\,\epsilon^{\frac{1}{\lambda}t}\,dt \quad \ldots\ldots\ldots (3)$$

and can be much simplified for the most important special cases by employing the appropriate value of $\frac{\partial u}{\partial t}$. For instance if the bath be maintained at constant temperature

$$(\theta - u_o) = (\theta_o - u_o)\,\epsilon^{-\frac{1}{\lambda}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

and if the temperature of the bath rise linearly with time (at rate r) the relation

$$u - \theta = r\lambda \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

will hold a short time after the introduction of the thermometer into the bath.

These equations are the source of the interpretations of λ given above. Other cases may be likewise developed, the results being somewhat more complex than (4) or (5). The equations furnish

a suitable basis for the development of methods of determining λ under a given set of conditions, and for computing the lag corrections in cases of applied thermometry where the corrections are appreciable.

Variation of λ with stirring, and the lag of a thermometer as a fluid current meter.—The lag of the same thermometer in water, viscous kerosene, and air, each forced past the bulb at different velocities covering a wide range, furnished the data from which is taken the table below. The method employed was to plunge a previously cooled thermometer into a fountain of the fluid, gushing out of one arm of a vertical U-tube, the other arm of this tube being connected to a source of supply maintained at constant temperature. A suitable throttle gave the desired current, which was measured by weighing the spill in a given time, or by a gas meter. The velocity of flow past the bulb was obtained from the current and area of the annular orifice.

TABLE 1

λ IN SECONDS. SMALL BULB "CHEMICAL" THERMOMETER

VELOCITY PAST BULB CENTIMETERS PER SECOND	0	1	5	10	50	100	500	1000	∞
Water.....	10	5.1	3.3	2.9	2.4	2.3			2.2 sec. any
Oil.....	40 to 50	13.4	7.5	6.4	4.8				medium
Air.....	190	170.0	148.0	128.0	71.0	58.0	33	25	(see note)

"Infinite stirring" means bringing the wall of the bulb instantaneously to its final temperature and maintaining it there by an "infinite" heat source while the average temperature of the thermometer changes from its initial to its final value. The λ corresponding to this condition should be a real constant of the thermometer, bearing no relation to the medium of immersion. The condition is probably very closely realized for a small thermometer when it is plunged into live steam, in view of the high latent heat of the steam, and the value 2.2 seconds was so obtained.

The agreement between observations taken at any one velocity was good, and the mean values, for the different velocities tested, gave points all of which were close to a smooth curve. Interpolation on this would seem, therefore, to be reliable, and the use of the method to determine velocities of flow of fluids is suggested.

The process of obtaining the data is tedious but the advantage is offered of a minimum of interference with the current to be measured. As an example of its application may be mentioned a determination of the flue draft of a continuous flow combustion calorimeter of the Junkers type, where it is evident that none of the more usual forms of anemometer could be used.

Lag of a Beckmann thermometer.—While the ordinary "chemical" thermometer was found to operate in close accord with the behavior predicted by equation (1), this was not the case for a thermometer with part of its bulb in good thermal contact with the immersion bath and part in very poor thermal contact owing to enclosure in a surrounding air jacket. The usual form of Beckmann instrument has a large capillary between the bulb and the fine capillary extending along the scale, and this large capillary, containing from 0.2 per cent to 0.5 per cent of the total mercury, is to be regarded as a secondary bulb of appreciable influence.

Assuming that equation (1) represents the behavior of the main bulb, with a lag λ_b, and that also such an equation represents the behavior of the large capillary, with a lag λ_c (much greater than λ_b) we can develop a theory analogous to the simpler one, but containing two λs. The equations are of course more complicated. For instance

$$\frac{\theta - u_0}{\theta_0 - u_0} = (1-k)\,\epsilon^{-\frac{1}{\lambda_b}t} + k\epsilon^{-\frac{1}{\lambda_c}t} \quad \ldots\ldots\ldots\ldots (6)$$

replaces (4). k is the fraction of the total mercury contained in the large capillary. Similarly (5) is replaced by

$$u - \theta = (1-k)\,r\lambda_b + kr\lambda_c \quad \ldots\ldots\ldots\ldots (7)$$

Methods of determining λ_b and λ_c were devised, and the actual behavior of a Beckmann thermometer, when plunged into a bath maintained at constant temperature, was found to be very closely represented by equation (6); in marked contrast to the failure of equation (4) in this respect. The assumptions made seem therefore to be justified and the theory based on them is offered as a better representation of the behavior of such a thermometer than is the simpler theory employing but one lag.

Electrical thermometers.—Electrical thermometers in common use fall into one of two classes, thermo-electric or resistance. Some form of galvanometer is necessary as an indicator for either, and the lag of this galvanometer is part of the total lag of the system, in fact often the only part which is appreciable.

Galvanometer lag.—From the fundamental equation of motion of a galvanometer, critically damped, it can be shown that the deflection follows an impressed e.m.f., changing linearly with time, so as to lag behind it by a constant time, numerically $4 \times \frac{\text{Moment of Inertia of Moving System}}{\text{Damping Coefficient (critical).}}$. This expression is simply related to the period, T, of the system when oscillating absolutely free, giving to the lag of the galvanometer the extremely simple form $\lambda = T/\pi$ seconds. For T may be substituted, without appreciable error, the period of the system when oscillating much underdamped, for this does not differ materially from T until the conditions are closely those of critical damping.

Resistance thermometers.—The equations developed from (1) have been found to represent fairly well the behavior of resistance thermometers as well as of mercurial thermometers, in approaching the temperature of a medium in which immersed. They were employed in determining the lag, in ice or well-stirred water, of a number of such thremometers. Thermometers of the Callendar type depart somewhat from following these equations, the departure being of the same general nature as that observed in the case of a Beckmann thermometer. The two term formulæ, with appropriate constants, proved to be rather better than the simpler ones, and may be said to be an empirical second approximation to the statement of the behavior of a Callendar type instrument. While a definite interpretation of all the various constants is lacking, a reason for such a double lag is in evidence. The temperature of the platinum coil is partly determined by that of the inner surface of the containing tube, of which the lag is relatively small, and partly by that of the support for the coil, of which the lag is relatively great.

The Callendar type of resistance thermometer was found to be slow in comparison with the average mercurial instrument.

The values obtained in vigorously stirred water ranged from 15 to 30 seconds, while for a mercury thermometer under the same conditions the usual value is between 2 and 6 seconds, except for the very largest bulbs. The Dickinson-Mueller type of resistance thermometer, an improved form of the instrument described in 1907, was found to be very much faster than a mercury thermometer. The only result of some attempts to measure directly the lag when immersed in well stirred water, was to ascertain definitely that it was but a small fraction of the lag of the galvanometer employed, which was about $1\frac{1}{2}$ seconds.

The Jaeger-Steinwehr method of computing the lag of a resistance thermometer.—Only a very meagre discussion of this method can be attempted here. It is probably the best, and perhaps in many cases the only possible way of determining the lag of such instruments as are constructed in a form permitting of applying it at all. The principle involved is the equating, in the equilibrium state, of the heat supplied to the thermometer by a small current, to the heat transferred to the bath because of the elevation of the temperature of the coil slightly above that of the bath. The lag and the heat capacity of the system whose temperature is so elevated, enter the equation together with other quantities which are readily measured experimentally. The possibility of determining the lag depends therefore upon whether or not a satisfactory estimate of the heat capacity factor can be made. In this respect the paper suggesting the method is decidedly misleading, stating for the proper value of the heat capacity that of the wire alone, the formula being reduced to terms of the dimensions, specific heat, specific resistance, etc., of the wire. Some portion of the supports of the coil, and the covering if there be one, must always be heated along with the coil, and in most cases the fraction to be included has several times the heat capacity of the wire in the coil. A thermometer of the Dickinson-Mueller type has, in the region of the platinum coil, an amount of mica whose heat capacity is about 0.15 calorie per degree. A probable distribution of the temperature gradient from the coil to the bath, places the portion to be included with the coil as about one-third, i.e., 0.05 calorie per ° C. The heat capacity of the coil

itself is 0.01 calorie per ° C. These figures lead to a value of λ of one-half second, for immersion in vigorously stirred water.

Thermo-electric thermometers.—The lag of a thermocouple, like that of a resistance thermometer, is almost entirely a question of the form of mounting. Depending upon the way of supporting and enclosing the junction, one would expect to find lags ranging all the way from a fraction of a second to perhaps 30 seconds, for immersion in water, and correspondingly greater values in air. With the wide latitude of variation in design without impairing the usefulness of the thermocouple, there have appeared almost as many forms of instruments as there are makers, in consequence of which it seemed unimportant to determine the lag of any particular form.

Thermometric lag in calorimetry.—Although the controversy concerning the effect of thermoelectric lag on calorimetric results may be said to have been settled by a recent conclusive paper published by W. P. White, the widespread attention attracted to the subject by the conflicting views expressed by eminent writers prior to the publication of the paper cited, has made it seem worth while to treat the subject rather fully in the more complete paper. An analysis, differing radically from that of White, will be found there, the conclusions being, however, substantially those stated by him.

BIOLOGICAL CHEMISTRY.—*The measurement of the oxidase content of plant juices.* H. H. BUNZEL, U. S. Department of Agriculture. Bulletin 238, Bureau of Plant Industry. 1912.

The very voluminous literature on the rôle and importance of oxidizing enzymes in many life processes of plants and animals makes a thoro study of their behavior, function, and distribution necessary. They

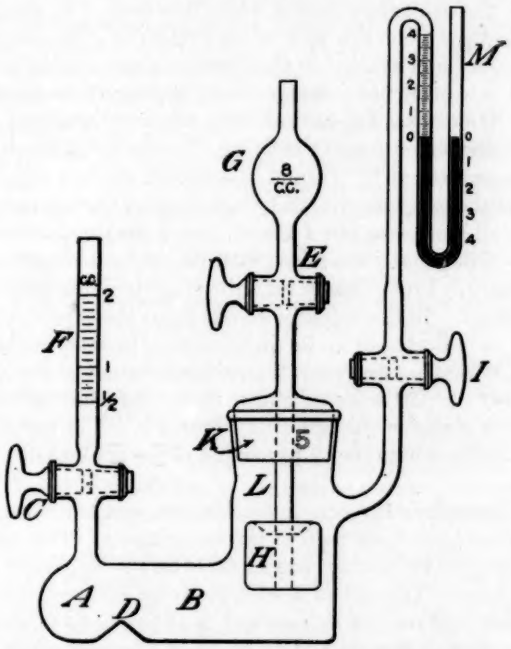

Fig. 1. Apparatus for measuring oxidase action

play an important part in certain pathological conditions, and in numerous industrial, and agricultural problems. As specific examples may be mentioned the work done by Woods, in the Bureau of Plant Industry, on the mosaic disease of tobacco, the work of Palladin and his school on the respiration of plants, and the causal relationship between the oxidases and color production as shown for plants by Palladin, and for animals by Gortner. They also play an important part in the darkening of tea, and the manufacture of the Japanese lacquer.

Nearly all of the experiments made thus far have not been carried on quantitatively because of the lack of satisfactory methods.

The method described is based on oxygen absorption. For this reason a constant temperature is essential. The apparatus in which the oxidations are carried out is shown in the text figure. Eight cubic centimeters of the solution of the substance to be oxidized are measured in the pipette *G* and allowed to run into the compartment *B*. The plant juice, the oxidizing power of which it is desired to study, is measured in pipette *F* and run into compartment *A*. Basket *H* holds 1 cc. of normal sodium hydrate to absorb the carbon dioxide formed in the process; *M* is a manometer charged with mercury to indicate the pressure within the oxidase apparatus. The whole apparatus is clamped to a specially constructed shaking machine. In the air-thermostat the temperature is brought to 37° C. and maintained at that point to within 0.1° thruout the experiment. Half an hour after the temperature of 37° is reached, all stopcocks but *I* closed, and a shaking machine set into operation. The plant juice mixes with the oxidizable material and the reaction begins. From time to time the shaking is interrupted and manometer is read. In the course of several hours the oxygen absorption is completed, as indicated by no further change of pressure within the flask. The ultimate reading expresses the oxidase content of the juice or extract towards the particular substance used. As a unit an oxidase solution is chosen of such a strength that 1 liter of it will be capable of bringing about the consumption by pyrogallol of the equivalent of 1 gram of hydrogen.

So far pyrogallol, tyrosin, hydrochinone, guaiacol, benzidine, and alphanaphthol have been used in the experiments. The concentration of the material to be oxidized has no effect on the end result provided it is used in excess. The carbon dioxide produced is absorbed by the alkali in the basket and may be determined at the end of the experiment by means of a special apparatus devised for the purpose. The result obtained is directly proportional, or at least nearly proportional, to the concentration of the oxidase present.

The method described was used successfully during the summer of 1911 at Utah in the study of the curly-top disease of sugar beets. In this study a very striking fact was brought out. It was found that the plants suffering from the curly-top disease have leaves with a much higher oxidase content than the normal, similarly, an unusually high oxidase content was observed in plants whose growth was stunted for other reasons, such as excessive watering, drought, or failure to produce seed. H. H. B.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The 79th meeting was held at the Shoreham Hotel, March 5, 1912. This was the annual open meeting at which the retiring President, Prof. W. J. SPILLMAN, presented his address on, *The present status of the genetics problem, which will appear in Science.*

The 80th meeting was held April 2, 1912. Dr. Errett Wallace and Messrs. L. H. Evans, S. M. McMurran and S. C. Stuntz were elected to membership. The following papers were read:

The celebration of the one hundredth anniversary of the Academy of Natural Sciences of Philadelphia: W. E. SAFFORD, delegate of the Botanical Society of Washington.

The meetings of the celebration were held on the evening of March 9, and during the two following days, in the new lecture hall of the Academy. A reception was given by the President of the Academy, Dr. Samuel G. Dixon, on the evening of March 20, and a banquet on the following evening at the Academy.

In enumerating some of the principal achievements of the Academy, Mr. Safford referred to the second arctic expedition of Dr. Kane, and to the more recent expedition of Peary, in 1891, which was wholly under the Academy's auspices. In speaking of the educational facilities offered by the Academy, he called attention to the fund left in trust by Mr. A. E. Jessup, for assisting young men to pursue studies in natural history. Some of its beneficiaries have become distinguished zoölogists and geologists.

Among the most valuable bequests and gifts received by the Academy are the botanical collections of the Rev. Lewis David von Schweinitz and of Dr. Charles W. Short, of Louisville, Ky., as well as the priceless collection of birds presented to the Academy by Dr. Thomas B. Wilson, which includes the types of Gould's *Birds of Australia.*

In conclusion Mr. Safford gave an account of the Academy's herbarium, of the Zoölogical Garden of Philadelphia, and the admirable Commercial and Economic Museum established in that city. This museum, which had for its nucleus, collections from Columbian Exposition of 1893, has received important additions from each subsequent exposition held in this country.

Studies in European herbaria with special reference to preservation of type specimens: W. T. SWINGLE. The speaker referred to his experiences during two visits in the past year to the principal European herbaria. The superiority of the European herbaria over the American in the cosmopolitan nature of their collections was emphasized. In many

respects, however, the herbaria both of Europe and America are managed much as they were a century ago. There is no adequate realization of the enormously increased facilities for travel and for the collection, shipment and preservation of perishable material. It would seem absolutely essential that directors of herbaria recognize the necessity of not only maintaining the usual collection of dried plants, but also full collections of fruits and of alcoholic material of delicate and characteristic portions of the plant such as inflorescences and parts of the flowers. Such collections are occasionally to be found, but are very rarely indexed so as to be easily accessible.

The increasing importance given to type specimens leads to a consideration of the best method of preserving them. The present method of leaving types with the other specimens, is certain to result in their rapid deterioration and ultimate loss. Type specimens should by all means be kept in a separate collection under special protection against fire and insect depredations and should be examined only in the presence of a custodian.

In considering type material it is important to recognize that in plants, type specimens can often be multiplied indefinitely simply by cutting branches from the same plant or by securing flowers or fruits from the same plant during successive years. These types which are secured from the same plant individual are designated as merotypes.[1] They are destined to become of very great importance in the future development of taxonomic botanical research. It is an easy matter nowadays when a new species of tree or shrub is found to mark the plant in a permanent way and to provide for supplying all the principal herbaria of the world with merotypes, by collecting material from this plant every time it comes into flower or fruit.

W. W. STOCKBERGER,
Corresponding Secretary.

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 494th regular meeting of the Society was held at the Cosmos Club on February 17, 1912. Under the head of brief notes E. M. Kindle exhibited lantern slides showing impressions made by tadpoles in the ooze of very shallow ponds and suggested a similar origin to many of the peculiar markings in rocks.

The first regular communication was by H. M. SMITH and LEWIS RADCLIFFE: *Notes on some remarkable deep sea fishes from the* Albatross *Philippine cruise.*

The first speaker referred in a general way to the reults of the *Albatross* expedition to the Philippine Islands, and then discussed some features of the fish collections from deep water. This region was an almost

[1] This word may be defined as follows: Merotype, (μέρος a part; τύπος a type) In taxonomy, a part of an organism that furnished the type specimen of a new species. It is obvious that merotypes are of importance only in case of perennial plants or of vegetatively propagated lower animals.

virgin field for deep-sea work, and time after time as the kam-trawl was hauled in depths of 100 fathoms and over, there were obtained species of fishes on which the human eye had never before gazed. Specimens and illustrations of a few of the more remarkable deep-water forms were shown, including a new family and several new genera of sharks, a new family and two new genera of pediculates, a new macruriod family, etc. Among the most noteworthy of the fishes referred to is a new noridanoid shark from the Sea of Mindanao which is intermediate between the two known families of the order, and is characterized by only five gill openings.

A few of the rarer deep-sea fishes were exhibited and commented upon by Mr. Radcliffe. Among these were specimens of *Ipnops murrayi* and *Halimochirurgus centriscoides* (the deep-sea snipe fish). Some comparative figures were presented showing the extent to which the collection will add to the known fish fauna of the region. One of the illustrations used was that of the family Macronsilæ, of which there are in the collection 1300 specimens referable to about forty species; only two species had previously been recorded from the Philippine Islands.

The two talks were illustrated by numerous drawings and specimens in alcohol.

The second communication was by A. S. Hitchcock: *Botanizing in Panama.*

As members of the Smithsonian Biological Survey, Mr. Hitchcock and his son visited Panama during the fall of 1912, remaining from August 24 to October 19, and, after a side trip to Central America, from December 14 to December 20.[1] From Culebra as headquarters, explorations were made, in the Canal Zone, the entire length of the Panama Railroad, and also at Toro Point, in the Savannas between Panama City and Old Panama, and at Taboga Island. Outside of the Canal Zone collections were made at Point Chamé and in the vicinity of Chorrera, and in western Panama on a trip to the Volcano Chiriqui.

There are extensive grassy savannas along the Pacific coast. The grasses are mainly species of Andropogon, Axonopus, and Paspalum. *Andropogon fastigiatus* and *Paspalum notatum* are typical of this region. Along the line of the Panama Railroad an abundant and aggressive introduced grass, *Panicum barbinode* (Pará grass) lines reservoirs and ditches and is found everywhere in moist soil where the native vegetation has been disturbed. It was found growing in Gatun Lake in 7 feet of water. Upon recently formed embankments it spreads rapidly by long strong stolons as much as 20 feet in length. *Panicum maximum* (Guinea grass), cultivated for forage, has abundantly escaped and is now common upon drier soil than that upon which Para grass flourishes. A conspicuous native species is *Paspalum fasciculatum* common along water courses and often abundant upon new ground. Another large species of Paspalum, rather rare in collections but common on banks in the Canal Zone is *P. saccharoides,* conspicuous because of its feathery inflorescence. Both these species produce stout stolons similar to those of Para grass. Herbarium

[1] See this Journal, 2: 142. 1912.

specimens rarely show stolons and many other habit features that are conspicuous and characteristic in the field. *Paspalum mucronatum*, common in Gatun Lake, produces long stolons that creep upon the surface of the water, being floated by means of inflated sheaths.

There is evidently considerable periodicity in the flowering time of grasses in Panama even in localities when the rainfall is fairly well distributed throughout the year. *Paspalum saccharoides* and *P. fasciculatum* mentioned previously were in full flower during September but in December not an inflorescence could be seen. On the other hand, *Panicum barbinode*, flowerless during the fall, was in full flower in December, while many species frequently observed in flower in Central America were in December just beginning to flower in the savannas of Panama, as for example, *Andropogon fastigiatus* and *A. brevifolius*.

There were collected in Panama 564 numbers, together with a large number of duplicates. These numbers probably represent about 200 species. It is interesting to note that Nees von Esenbeck lists in Seeman's Flora of Panama, 27 species of grasses.

This communication was profusely illustrated by lantern views.

D. E. LANTZ, Recording Secretary.

PROGRAMS AND ANNOUNCEMENTS

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 709th meeting will be held at the Cosmos Club, Saturday evening, April 20, 1912, when MR. ALEXANDER MACFARLANE will give (by invitation) an *Account of Researches in the Algebra of Physics*.

THE CHEMICAL SOCIETY

The Centennial of the Gas industry will be commemorated by a meeting on Wednesday May 1, 1912, at the Institute of Industrial Research.